A Two-Dimensional Position-Sensitive MWPC for Fission Fragments

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A TWO-DIMENSIONAL POSITION-SENSITIVE MWPC FOR FISSION FRAGMENTS

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A low-pressure, multiwire proportional counter, developed for heavy-ion-induced fission fragment detection is described. The active area is 8×10 cm^2. It is position sensitive in two dimensions with a resolution of better than 1.5 mm for both x and y. The time resolution is 175 ps. The detector can withstand count rates greater than 100 kHz.

1. Introduction

There is, at present, considerable interest in studies of fission-related phenomena in heavy-ion reactions [1]. One type of detector commonly used in such studies is the Parallel Plate Avalanche Counter (PPAC) [2–4]. They consist of two parallel electrodes, one of which is usually position sensitive in one dimension with an optional wire plane in between the electrodes to provide position sensitivity in the other dimension. In these detectors, the anode collects the fast electrons released in the avalanche. Pulses induced on the cathode and wires provide the position information [3,5].

Another type of detector that can be used for the detection of fission fragment-type particles is the multiwire proportional wire counter (MWPC) [6]. These detectors also consist of two electrodes and a central wire plane; the multiplication takes place on the anode wires, and the induced pulse on the cathode provides position information. Recently, Breskin has shown [7,8] that MWPCs operated around pressures of 2 Torr can be used for very fast timing purposes. This is believed to be due to a double amplification process achieved at low gas pressures: (1) amplification in the "PPAC" region far from the wires, where the electrical field is approximately constant; (2) a second amplification step in the vicinity of thin (10 μm diameter) anode wires. A small (2×2 cm^2) detector employing this double amplification process was reported in ref. 9.

We have constructed a MWPC, which is essentially a large (8×10 cm^2) version of this detector [9] and made position sensitive in both x and y dimensions by dividing the cathodes into vertical and horizontal strips. The detector is also designed to operate at low (typically 2 Torr) gas pressures. These detectors have been satisfactorily used in heavy-ion induced-fission experiments [10]. Results of tests performed on these detectors are presented in this paper.

2. Construction and operation

The detector consists of a central wire plane that acts as an anode, with cathodes on each side at ground potential. The electrode frames are all made of G10 material; the spacing between the wire-plane anode and each cathode is 3.2 mm. The active area of the detector is 8×10 cm^2. The anode wires are 10 μm diameter gold-plated tungsten wires and are mounted on a frame at a spacing of approximately 1 mm. At the edges, the five last wires are thicker in order to minimize sparking problems. The diameter is increased gradually through 20, 30, 50, 75 to 100 μm. The cathodes are foils made of polypropylene on which gold strips are evaporated. The polypropylene is stretched to a thickness of about 75 μg/cm^2 using the device described in ref. 11, and mounted on the electrode frame. Gold is then evaporated through a mask, yielding parallel gold strips with a thickness of 75 μg/cm^2. The width of the gold strips is defined by the evaporation mask, and is 3 mm for the horizontal (x) dimension and 5 mm for the vertical (y) dimension. The gap between two consecutive strips is 0.5 mm in both cases. The detector is mounted on the flange of an aluminum box for easy access (see fig. 1). This box is the gas container and has entrance and exit windows. These pressure windows also consist of stretched polypropylene with a thickness of about 75 μg/cm^2. The windows are supported by 100 μm diameter stainless steel wires, two vertically and one horizontally mounted.

The detectors usually operate at a pressure of 2 Torr isobutane. At this pressure, the sparking limit is around 540 V (for CP-grade counting gas without purifying filter). The gas flow and pressure in the detector are regulated by means of precision metering valves. The differential pressure over the detector is monitored by means of a Baratron [12] pressure gauge. At a working voltage of 500 V and 2 Torr gas pressure, the fast anode

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Fig. 1. Photograph of two MWPCs, mounted on their flanges.

pulses produced by fission fragments typically have an amplitude of 10 mV and a rise time of 3 ns; the pulses induced on the position sensitive cathodes have amplitudes of 2 mV.

The position-sensitive cathodes are read out by means of PE9821 delay lines [13], which contain 10 delays of 5 ns each. The rise time is 8.5 ns, and the characteristic impedance is 50 Ω. The gold strips are grounded via a 10 kΩ resistor. Signals are extracted from both ends of the delay line chain with 50 Ω coax cables. One thus obtains four timing signals, which are used to determine the position. The signals from the two cathodes (left/right and up/down) are subsequently connected to four "stop" inputs of a CAMAC TDC. The "start" pulse is generated by the (fast) anode signal, gated by the logical requirements of the specific experiment.

3. Experimental results

The detectors described in this paper have been tested extensively, both with a ^{252}Cf(sf) source as well as in various beams from the Los Alamos and Brookhaven National Laboratory tandem Van de Graaff accelerators [10].

An example of the position sensitivity of the detector is shown in fig. 2. The detector was irradiated with fission fragments of ^{210}Po, induced by the $^{12}C + ^{198}Pt$ reaction at 80 MeV beam energy. Plotted in fig. 2 is a contour map of a two-dimensional spectrum, horizontal position (x-axis) and vertical position (y-axis). In front of the detector, a mask was positioned with a 1×1 cm^2 hole pattern. These holes have a diameter of 1.5 mm. Two holes were plugged for calibration purposes. The spectra plotted in fig. 3 show part of the projections of the above contour plot. Two peaks 1 cm apart are shown for each dimension (horizontal and vertical). We conclude from these results that the position resolution is better than 1.5 mm fwhm in both dimensions. This is thus actually about a factor of three smaller than the width of the gold strips.

Fig. 4 shows an anode pulse height spectrum, measured by scattering of 93 MeV Br-ions from the Los Alamos tandem from a 160 μg/cm^2 Au target. The detector was positioned at a forward angle of 30° at a distance of 25 cm from the target. An additional "start" detector [9] was mounted between the target and the detector in order to measure the flight time of the particles. One can clearly see two peaks in the spectrum: one due to the scattered Br-ions, the other caused by the recoiling Au ions. In the time spectrum measured between the start and stop detectors both peaks from Br- and Au-ions are clearly separated. By means of software gates on these peaks, one can separate both ions in the energy-loss spectrum as indicated in fig. 4.

The time resolution of the detector is measured with 150 MeV ^{32}S ions from the Brookhaven tandem, elastically scattered from a 210 μg/cm^2 ^{126}Te target. Two identical detectors were placed in one box, one behind the other at a distance of 5 cm. The detector box was positioned in the forward direction around 0°, with a 1 cm diameter cup in front at a distance of 10 cm. The result is shown in fig. 5. This spectrum was obtained using a 2.5 mm software gate on the horizontal position.

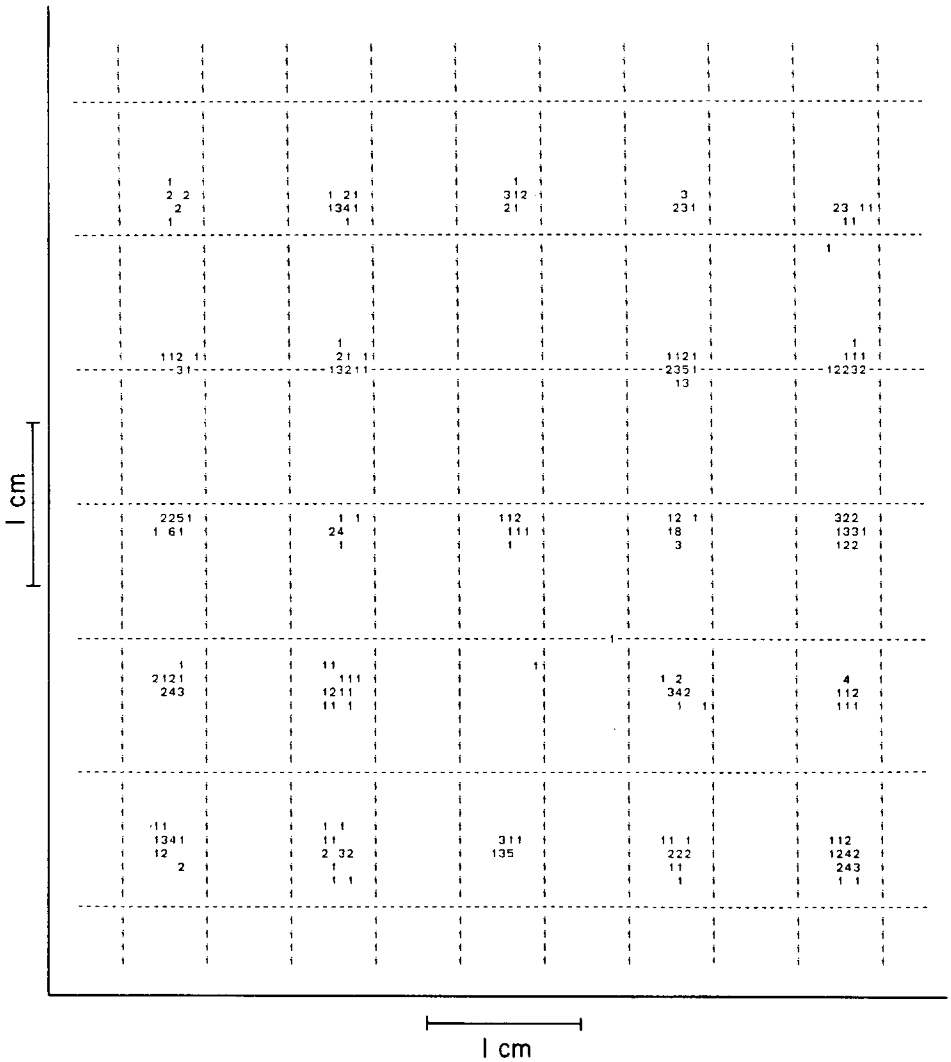

Fig. 2. Contour plot of a two-dimensional position spectrum, horizontal (x-axis) vs vertical (y-axis). The detector was irradiated through a mask with 1.5 mm diam. holes 1 cm apart.

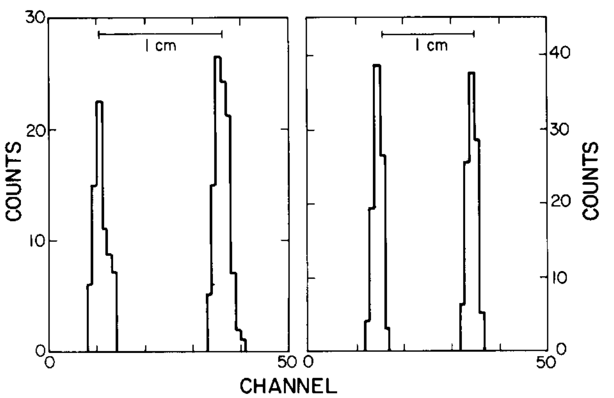

Fig. 3. Vertical (*left*) and horizontal (*right*) position spectra measured through a mask with 1.5 mm diam. holes 1 cm apart.

In this way, a time resolution between the two detectors of 250 ps fwhm is obtained. We conclude that the intrinsic time resolution of a single detector is 175 ps, even at a total count rate of 100 kHz or more. The position of the time peak does not depend on the position in the detector. Without a gate on the position, the time resolution between the two detectors measures to 400 ps fwhm.

For the light heavy ions like ^{12}C and ^{16}O at beam energies around 100 MeV, the time resolution is considerably worse (around 700 ps per detector) due to the low energy loss.

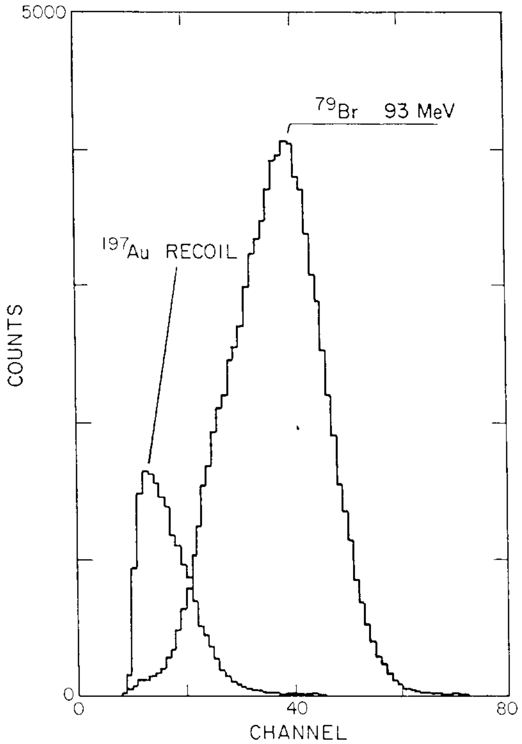

Fig. 4. Energy loss spectrum for 93 MeV Br-ions scattered from an Au target showing the elastic Br-ions and the recoiling Au-nuclei. Both are separated by timing.

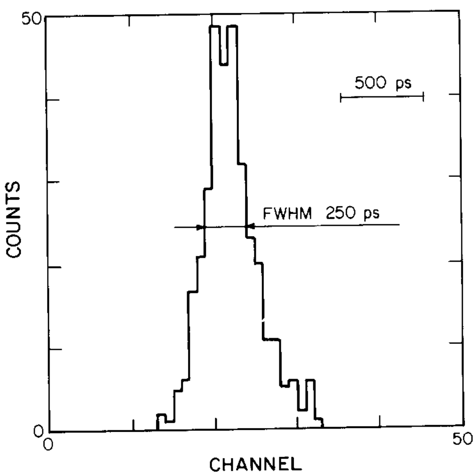

Fig. 5. Time spectrum measured with two MWPCs, one behind the other at a distance of 5 cm. The reaction was $^{32}S + ^{126}Te$ at 150 MeV. There is a 2.5 mm gate on the horizontal position.

4. Conclusion

A low-pressure MWPC has been built for the detection of fission fragments. It is position sensitive in two dimensions using thin gold strips on both the entrance- and exit-cathode foils. The operation at low gas pressures enables the utilization of a double multiplication process: the first one in the high constant field region, the second one in the vicinity of the anode wires.

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